PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :		(11) International Publication Number: WO 92/14912
F01N 3/20, 3/28	A1	(43) International Publication Date: 3 September 1992 (03.09.92)

(21) International Application Number: PCT/SE92/00101

(22) International Filing Date: 20 February 1992 (20.02.92)

(30) Priority data:
9100541-3 22 February 1991 (22.02.91) SE

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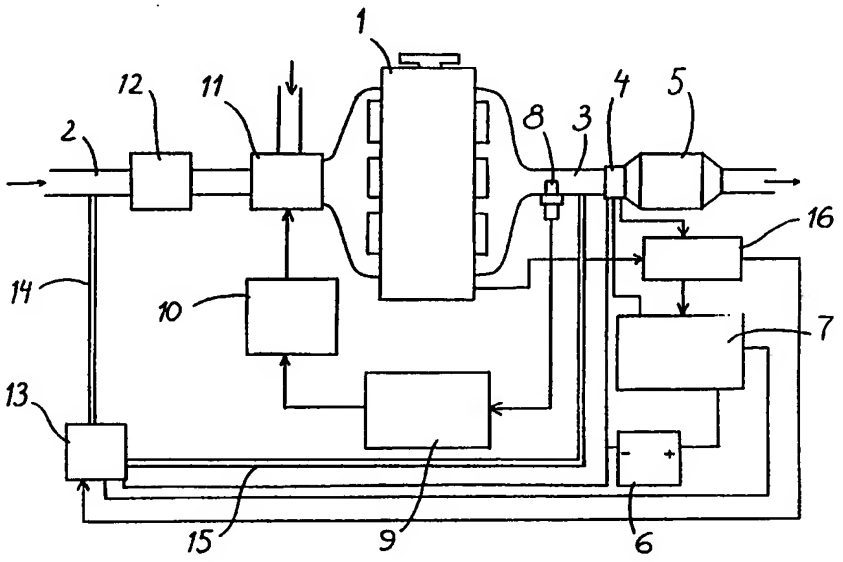
(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, KR, LU (European patent), MC (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.
With amended claims.
In English translation (filed in Swedish).

(54) Title: A METHOD AND A DEVICE FOR CATALYST EMISSION CONTROL



(57) Abstract

The invention concerns a method and a device for catalyst emission control in motor vehicles. An emission control system in accordance with the invention comprises an electrically heated start-up catalyst (4) which is positioned adjacent a main catalyst (5) in the exhaust pipe (3) associated with the engine (1). In addition are provided a source of current (6), a switch (7), a control unit (16), a lambda sensor (8), and an electrically operated air pump (13) including an air channel inserted between the lambda sensor (8) and the start-up catalyst (4). In connection with start-up of the engine (1) the start-up catalyst (4) and/or the air pump (13) are activated by means of the control unit (16). The invention provides improved purification of the exhaust gases emitted by the engine (1).

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A METHOD AND A DEVICE FOR CATALYST EMISSION CONTROL

The subject invention concerns a method for catalyst emission control in vehicles comprising an engine having an inlet pipe and an exhaust pipe and wherein an electrically heated start-up catalyst and a main catalyst are placed adjacent one another in the exhaust pipe. The invention likewise concerns a device for performing the method.

New and stricter legislation, particularly in the USA, with respect to future limitations on air-pollutant emission levels makes it increasingly desirable to achieve more efficient emission control in motor vehicles. Today, catalyst emission control devices are those most commonly used. However, they are not capable of operating at their maximum purification efficiency during the vehicle cold-start period. Consequently, a large proportion of the air-polluting exhaust gases emitted from the present catalyst-equipped motor vehicles are generated during the heating-up period of the catalyst, a period which lasts until the catalyst reaches its operational temperature (approx. 250 to 400° C). In the case of cold starts, this period may last several minutes and therefore creates a problem.

Catalysts of traditional type may be supplemented with an additional electrically heated start-up catalyst. A device of this kind is previously known from Patent Publication WO 89/10470. By heating the start-up catalyst electrically during the engine start-up it becomes possible to shorten the heating-up period of the catalyst package as a whole.

The subject invention provides improved purification of the exhaust gases in motor vehicles whereby the emission of pollutants may be controlled to within the stipulated levels. This is achieved by means of a method of the kind

defined initially which is characterized in that in connection with the engine start-up a flow of air is supplied into the exhaust pipe through an air channel debouching upstream of the start-up catalyst, and in that this flow is interrupted at the latest when the main catalyst reaches its light-off temperature.

The invention will be described in the following with reference to one embodiment thereof and to the annexed drawing figure 1, showing an emission control system in accordance with the invention.

The system illustrated in the drawing figure is intended to purify the exhaust gases from a combustion engine 1, which could be either of the traditional gasoline-fuelled type, or be intended for alternative fuels such as LPG, natural gas or alcohol fuels. The engine is equipped with an inlet pipe 2 and an exhaust pipe 3. The exhaust gases from the engine 1 are conducted through a catalyst package comprising an electrically heated start-up catalyst 4 and a main catalyst 5 which is connected to the start-up catalyst. The main catalyst 5 is of standard type, consisting e.g. of a round ceramic substrate 4.66" X 6", 400 cpsi (cpsi=cells per square inch), with a PM loading of 50 g/ft^3 (PM = precious metal) and a relationship Pt/Rh of 5:1. The start-up catalyst 4 is mounted upstream of the main catalyst 5 at a distance therefrom amounting to 0.1-5 times, and preferably 1.5 - 2.0 times, the length of the support structure of the start-up catalyst, in order to achieve favourable flow and temperature conditions.

The start-up catalyst 4 comprises a tubular metal catalyst-coated housing (e.g. having a diameter of 90 cm, a length L of 28 cm, 200 cpsi, with a PM loading of 60 g/ft^3 and a relationship Rt/Rh of 5:1) of a particularly heat-resistant nature. The catalyst support inside the metal housing acts as a resistive load which may be

connected to a source of current for heating.

In addition, the start-up catalyst is connected to a battery 6 which as a rule is the normal vehicle starter battery. In some cases, the normal vehicle starter battery capacity is insufficient for the current needs of the start-up catalyst 4, in which case a separate electric energy supply system may be required.

To connect the start-up catalyst 4 to the source of current, an electronical switch 7 is inserted between the catalyst 4 and the battery 6. The switch preferably is of semi-conductive type to minimize losses and ensure reliable connection of current to the start-up catalyst 4 without risks for the generation of electro-magnetic pulses, a phenomenon that otherwise frequently occurs in vehicles. The switch 7 could also be of a relay-type.

Upstream from the start-up catalyst 4 a sensor, known as a lambda sensor 8, is positioned for the purpose of detecting the presence of oxygen in the exhaust gases. The lambda sensor 8 is connected to an electronic unit 9 for adaptation of the signals from the lambda sensor 8 to a correction unit 10. The correction unit 10 is designed to determine and emit a signal relating to the air/fuel mixture to the injection unit 11 of the engine 1. The injection unit 11 preferably is of a type commonly used in this position as is also an air quantity meter 12 incorporated in the system.

The system also comprises an electrically controlled air pump 13 to which air is supplied through a first air channel 14, the latter being connected to the inlet pipe 2 of the engine 1 upstream from the air quantity meter 12. The air pump 13 may be operated to supply air into the system upstream from the catalyst package 4, 5 through a second air channel 15 which is connected to the exhaust

pipe 3 at a point between the lambda sensor 8 and the start-up catalyst 4. The air pump 13 comprises a check valve (not shown) serving to protect the air pump 13 from any hot back-flow exhaust gases that may flow towards the air pump 13. To energize the air pump 13, the latter is connected to an output terminal of the electronic switch 7, which terminal is independent of the operation of the start-up catalyst 4.

The system also comprises a computer-based control unit 16 which is connected to and designed to emit control signals to the switch 7 and the air pump 13. A temperature sensor (not shown) is likewise connected to the control unit 16, said sensor being positioned adjacent the start-up catalyst 4 and arranged to supply a signal representative of the temperature of the start-up catalyst 4. The temperature sensor may be a sheath-type resistance thermometer which is integrated with the start-up catalyst 4 during the manufacture thereof. In this way, the temperature of the start-up catalyst 4 may be monitored accurately.

The control unit 16 serves to regulate the operation of the start-up catalyst 4 on a time basis and/or with regard to temperature, to monitor the start-up catalyst 4 including the temperature sensor, to monitor current supply to the start-up catalyst 4 from the battery 6 and, as the case may be, from the vehicle electricity generator (not shown) and also to control the air pump 13 operation with regard to amounts of flow. Current supply monitoring is effected by voltage measurement, not to be described in any detail here, related to the starter battery circuit. Monitoring of the start-up catalyst 4 is effected by measuring its resistance, which will not be described here in any detail.

In the following, the function of the emission control

system of the invention will be described. When the engine 1 is started, the above-mentioned current supply monitoring activity results in a check being made as to the capacity of the battery 6 to supply sufficient energy to the start-up catalyst 4. If the energy contents of the battery 6 are found to be sufficient and if the monitoring conditions of the start-up catalyst are normal, the process for heating the start-up catalyst 4 will be initiated. At the same time, the additional air supply via the air pump 13 will start. The heating and the air supply continue for a predetermined period or until a predetermined temperature is reached in the start-up catalyst 4. These conditions correspond to the obtainment of the light-off temperature in the catalyst package 4, 5 as a result of the electrical heating and exothermal reactions. At this point, the air injection and the heating are cut off.

It should be pointed out that normally, there is no supply of air after obtainment of the light-off temperature of the catalyst package 4, 5, since such supply would have an unfavourable effect on the NOx-emissions, and also that the heating of the start-up catalyst 4 may be effected irrespectively of the air supply via the air pump 13.

In accordance with the embodiment described, the switch 7 is activated in such a manner that the process of heating the start-up catalyst 4 is initiated directly following ignition of the engine 1 (after the so called engine "cranking" process). It may also be desirable to preheat the start-up catalyst 4 prior to engine cranking, alternatively to heat it before as well as after the cranking process. However, it may be disadvantageous to activate the start-up catalyst 4 while the vehicle starting motor is operating, since the latter may need the entire capacity of the battery 6. The heating increases the temperature of the exhaust gases flowing

through the start-up catalyst 4 when these exhausts are conducted into the main catalyst 5, with the result that the complete catalyst package 4, 5 will reach its light-off temperature more quickly, i.e. the temperature at which the catalyst package 4, 5 is sufficiently heated to operate with an acceptable purification efficiency.

The flow of air from an activated air pump 13 is intended to contribute to a comparatively lean exhaust gas mixture being directed to the catalyst package 4, 5 during the heating-up period of the latter, i.e. the exhaust gas mixture inside the exhaust pipe 3 is to have a small excess of oxygen. Since it takes about 30 seconds for the lambda sensor 8 to reach its full efficiency level, thus allowing the engine 1 to run at the stoichiometric ratio, the lambda sensor system cannot be used to regulate the air supply to the catalysts 4, 5 during this period. Air supply downstream from the lambda sensor 8 may, however, result in a controlled excess of oxygen being supplied to the exhaust gases flowing to the start-up catalyst 4 during the start-up, the heating-up and the early driving phase of the engine 1. In this manner the function of the lambda sensor 8 will not be disturbed by the flow of air supplied from the air pump 13, since the air injection takes place downstream from the lambda sensor 8.

It has been found that an excess of oxygen in the order of 1% (as compared to the stoichiometric amount of 0.63% oxygen) gives a decrease of the catalyst light-off temperature by 20 - 30°C (with respect to control of HC and CO) whereas an excess of oxygen in the order of 2% gives a corresponding decrease of the light-off temperature by 30 - 50°C. Also the light-off temperature with respect to the control of the NOx emissions may be improved by an excess of oxygen in the exhaust gas mixture.

When the heating of the start-up catalyst 4 is cut off, there is a sudden temperature drop with resulting cooling of the start-up catalyst 4, which in turns leads to a reduction of the degree of purification obtained. However, together with the existing cool and rich exhaust gas composition, such cooling has the effect that the main catalyst 5 will react in such a manner that a transient temperature increase will take place in its catalytic material before it is cooled off. This phenomenon is sometimes referred to as "wrong way behaviour" and is disclosed in 'Transients of Monolithic Catalytic Converters: Response to Step Changes in Feedstream Temperature as Related to Controlling Automobile Emissions', Se H. Oh & James C. Cavendish, General Motors Research Laboratories, Warren, Michigan 48090, USA, Ind. Eng. Chem. Prod. Res. Dev., Vol. 21, No. 1, 1982. This effect may be made use of in the following manner. The emission control system in accordance with the invention may be arranged in such a manner that via the control unit 16 and the switch 7 a pulsating current is supplied to the start-up catalyst 4, said current pulses causing rapid temperature increases followed by temperature reductions in the start-up catalyst 4. In combination with the pre-requisite that on the one hand the current supply capacity is sufficient (i.e. the power supply to the start-up catalyst 4 is sufficiently high) and on the other that the geometrical position of the start-up catalyst 4 is at a distance from the main catalyst 5 of preferably 1.5 to 2.0 times the length of the supporting structure of the start-up catalyst 4, the result will be "wrong way behaviour" of the catalyst package 4, 5, which signifi-cantly contributes to a reduction of the time required before the catalyst package 4, 5 reaches its light-off temperature.

It should be pointed out, that parameters such as current

intensity prior to supply to the start-up catalyst 4 and the geometry of the location of the start-up catalyst 4 in relation to that of the main catalyst 5, may be adjusted in response to the needs of the specific applications of the system.

It should furthermore be pointed out that a system in accordance with the invention may be controlled by heating of the start-up catalyst 4 without air injection from the air pump 13 and vice versa. The total effect of the emission control achieved by the catalyst package 4, 5 in the case of heating combined with air injection does, however, surpass the level of control achieved from each one of these functions separately.

Further improved purification efficiency is achieved when the control unit 16 is arranged to actuate the air pump 13 in such a manner that the air supply is optimized with regard to the flow of exhaust gases instead of maintaining the air supply at a constant level as indicated above. In this case, the air pump 13 must be capable of allowing a variable flow of air into the exhaust pipe 3. The amount of the excess of oxygen in the exhausts may then be varied on a time basis upon activation of the air pump 13. For instance, the flow may be dimensioned in such a manner that the excess of oxygen in the exhaust gases is decreased step by step in order to optimize the purification efficiency of the catalyst package 4, 5.

CLAIMS

1. A method in catalyst emission control in vehicles comprising an engine (1) having an inlet pipe (2) and an exhaust pipe (3) and wherein an electrically heated start-up catalyst (4) and a main catalyst (5) are placed adjacent one another in the exhaust pipe (3), c h a r a c t e r i z e d in that in connection with the start-up of the engine (1) a flow of air is supplied to the exhaust pipe (3) via an air channel (15) debouching into said pipe upstream from the start-up catalyst (4), and in that the flow is interrupted at the latest when the main catalyst reaches its light-off temperature.

2. A method as claimed in claim 1, c h a r a c t e r i z e d in that the flow is interrupted after a certain predetermined time period t_1.

3. A method as claimed in claim 1 or 2, c h a r a c t e r i z e d in that the start-up catalyst (4) is activated in connection with the start-up of the engine (1), and is deactivated after a certain predetermined time period t_2.

4. A method as claimed in claim 2 and 3, c h a r a c t e r i z e d in that the time periods t_1 and t_2 coincide.

5. A method as claimed in claim 3 or 4, c h a r a c t e r i z e d in that the start-up catalyst (4) is activated by a pulsating current of sufficient power to ensure that a rise of the temperature in the catalysts (4, 5) in accordance with the so called "wrong way behaviour" will occur.

6. A method as claimed in any of claims 1-5, c h a r a c t e r i z e d in that the flow of air which is supplied to the exhaust pipe (3) is dimensioned in such a way as to

produce contents of oxygen in said exhaust gases of 0-5 % above the stoichiometric oxygen level.

7. A method as claimed in any of claims 1-6, c h a r a c - t e r i z e d in that the flow of air which is supplied to the exhaust pipe (3) is dimensioned in such a way as to optimize the contents of oxygen with respect to the flow of exhaust gases.

8. A device for performing the method according to any of claims 1-7, c h a r a c t e r i z e d by a source of air (13) which is connected to the exhaust pipe (3) through the air channel (15) debouching into said exhaust pipe (3), and a control unit (16) which is connected to said source of air (13) and arranged to, in connection with the start-up of the engine (1), activate a flow of air from the source of air (13) to the exhaust pipe (3).

9. A device as claimed in claim 8, wherein there is provided a lambda sensor (8) in the exhaust pipe (3), c h a r a c t e r i z e d in that the air channel (15) is debouching into the exhaust pipe (3) upstream from the main catalyst (4) but downstream from the lambda sensor (14).

10. A device as claimed in claim 8 or 9, c h a r a c t e - r i z e d in that the start-up catalyst (4) is positioned in said exhaust pipe (3) upstream from the main catalyst (5) at a distance therefrom amounting to 0,1 to 1,5 times, preferably 1,5 to 2,0 times, the length of the support structure of the start-up catalyst (4).

AMENDED CLAIMS

[received by the International Bureau on 13 July 1992 (13.07.92); original claims 1-10 replaced by amended claims 1-9 (2 pages)]

1. A method in catalyst emission control in vehicles comprising an engine (1) having an inlet pipe (2) and an exhaust pipe (3) and wherein an electrically heated start-up catalyst (4) and a main catalyst (5) are placed adjacent one another in the exhaust pipe (3), c h a r a c t e - r i z e d in that in connection with the start-up of the engine (1), when the exhaust gas mixture is rich, the start-up catalyst (4) is activated by a pulsating current of such a nature as to produce alternate increases and reductions of the temperature of the exhaust gases, and in that the temperature changes are transmitted to the main catalyst (5) through the exhaust gas mixture in such a manner that said main catalyst reacts by increasing its temperature in accordance with the so called "wrong way behaviour" phenomenon.

2. A method as claimed in claim 1, c h a r a c t e - r i z e d in that a flow of air is supplied to the exhaust pipe (3) via an air channel (15) debouching into said pipe upstream from the start-up catalyst (4).

3. A method in catalyst emission control in vehicles comprising an engine (1) having an inlet pipe (2) and an exhaust pipe (3) with a catalyst (5) mounted therein, wherein in connection with engine start-ups a flow of air is supplied to the exhaust pipe (3) through an air channel (15) debouching into said pipe upstream from said catalyst (5) in order to produce an excess of oxygen, particularly as defined in any one of claims 1 or 2, c h a r a c t e - r i z e d in that the flow of air supplied to the exhaust pipe (3) is regulated to effect a succesive reduction of said flow, beginning at a predetermined starting level.

4. A method as claimed in claim 3, c h a r a c t e -

r i z e d in that the flow of air supplied to the exhaust pipe (3) is regulated to produce contents of oxygen in said exhaust gases of between 5 to 0% above the stoichiometric oxygen level.

5. A method as claimed in claim 4, c h a r a c t e r i z e d in that the oxygen contents of the exhaust gases are reduced stepwise.

6. A device for performing the method according to claim 1 or 2, c h a r a c t e r i z e d by a switch (7) and a control unit (16), said control unit (16) being arranged to emit control signals to said switch (7) to provide said start-up catalyst (4) with a pulsating current.

7. A device as claimed in claim 6, c h a r a c t e r i z e d in that the start-up catalyst (4) is positioned in said exhaust pipe (3) upstream from the main catalyst (5) at a distance therefrom amounting to 0,1 to 5,0 times, preferably 1,5-2,0 times, the length of the support structure of the start-up catalyst (4).

8. A device for performing the method according to any one of claims 3-5, said device comprising a source of air (13) which is connected to the exhaust pipe (3) through the air channel (15) debouching into said exhaust pipe (3), c h a r a c t e r i z e d in that the flow of said source of air (13) may be regulated by a control unit (16) which is connected to said source of air (13) and which is arranged to regulate the flow of air from the source of air (13) to the exhaust pipe (3).

9. A device as claimed in claim 8, c h a r a c t e r i z e d in that the control unit is arranged to regulate the flow so as to maintain an excess of oxygen in said exhaust gases that is constant compared with the stoichiometric ratio.

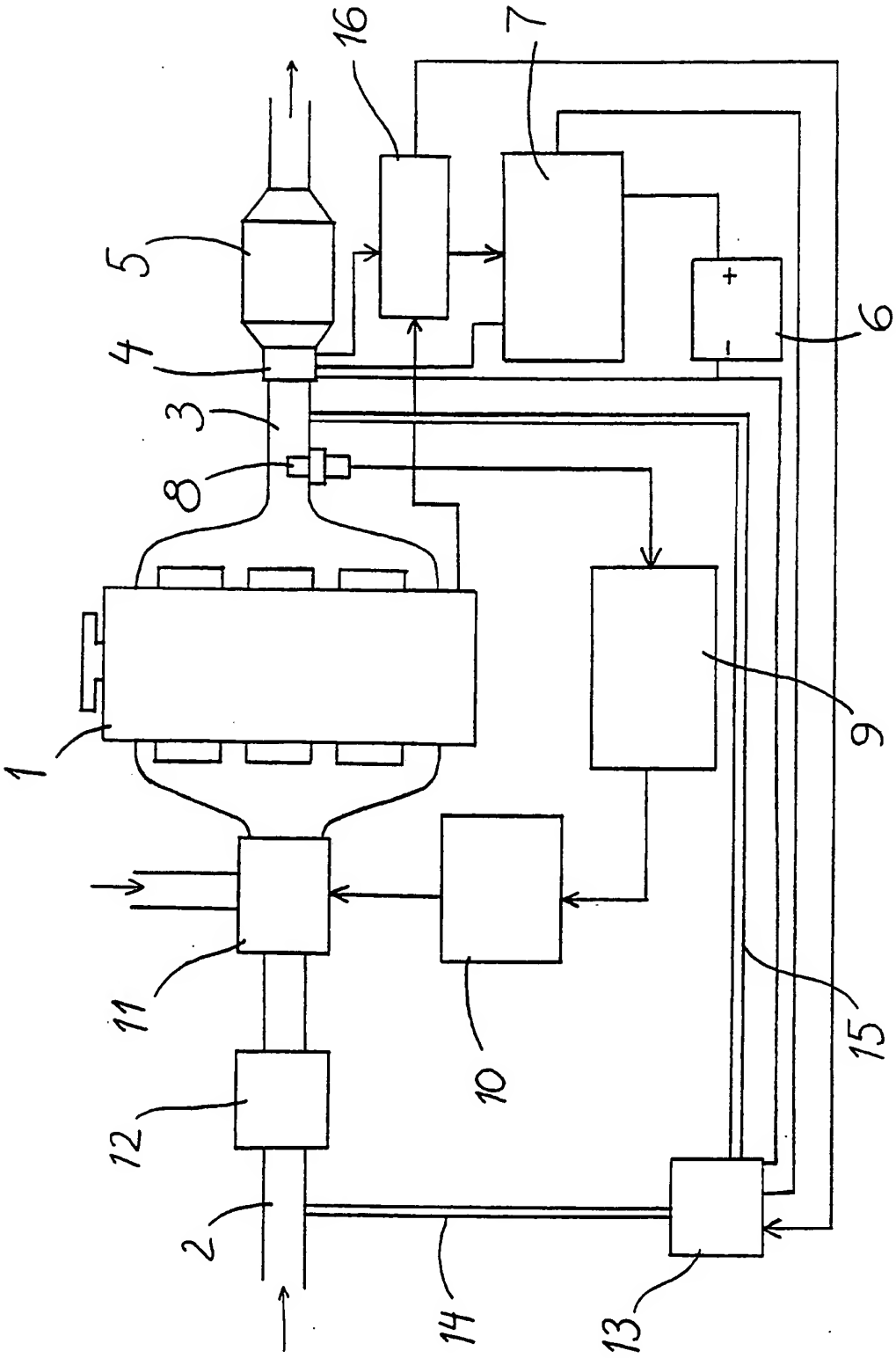

Fig. 1

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE 92/00101

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: F 01 N 3/20, 3/28

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	F 01 N

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
Y	US, A, 4976929 (RICHARD C. CORNELISON ET AL) 11 December 1990, see abstract --	1-10
Y	WO, A1, 8910470 (EMITEC GESELLSCHAFT FÜR EMISSIONSTECHNOLOGIE MBH) 2 November 1989, see abstract --	1-10
Y	DE, A1, 3506235 (VOLKSWAGENWERK AG) 19 September 1985, see abstract; figure 1; claims 1-7 --	1-10
Y	Patent Abstracts of Japan, Vol 12, No 222, M712, abstract of JP 63- 18122, publ 1988-01-26 (MAZDA MOTOR CORP) --	1-10

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
24th April 1992	1992 -05- 22
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	Johan von Döbeln

Form PCT/ISA/210 (second sheet) (January 1985)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 4125997 (JÖRG ABTHOFF ET AL) 21 November 1978, see column 1, line 40 - line 46; abstract; figure 1 --	1-10
A	EP, A1, 0412521 (OBERLAND MANGOLD GMBH) 13 February 1991, see column 1, line 33 - line 42; figure 1; claim 1 --	1

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/SE 92/00101

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 28/02/92
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A- 4976929	90-12-11	NONE		
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		DE-U-	8816514	89-10-26
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